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Skolkovo Institute of Science and Technology

Jury Member Report – Doctor of Philosophy thesis.

Name of Candidate: Timur Bulatov

PhD Program: Petroleum Engineering

Title of Thesis: Lithological and geochemical study of type I kerogen in the Bazhenov Formation in application to exploration and production of hydrocarbons

Supervisor: Professor Mikhail Spasennykh

Name of the Reviewer: Prof. Naima HAMOUMI

I confirm the absence of any conflict of interest	**Date: 05-10-2022**

The purpose of this report is to obtain an independent review from the members of PhD defense Jury before the thesis defense. The members of PhD defense Jury are asked to submit signed copy of the report at least 30 days prior the thesis defense. The Reviewers are asked to bring a copy of the completed report to the thesis defense and to discuss the contents of each report with each other before the thesis defense.

If the reviewers have any queries about the thesis which they wish to raise in advance, please contact the Chair of the Jury.

Reviewer's Report

Reviewers report should contain the following items:

- Brief evaluation of the thesis quality and overall structure of the dissertation.
- The relevance of the topic of dissertation work to its actual content
- The relevance of the methods used in the dissertation
- The scientific significance of the results obtained and their compliance with the international level and current state of the art
- The relevance of the obtained results to applications (if applicable)
- The quality of publications

The summary of issues to be addressed before/during the thesis defense

Brief evaluation of the thesis quality and overall structure of the dissertation.

The thesis manuscript of Timur Bulato, entitled submitted to obtain the PhD degree at Skolkovo Institute of Science and Technology, Moscow focuses on "The lithological and geochemical study of type I kerogen in the Bazhenov Formation (Western Siberia) in application to the exploration and production of hydrocarbons". It consists of 95 pages, and it is organized in six chapters including conclusion, and summary, and supplemented with a table of content, a list of the author's publications, a list of figures, a list of abbreviations and symbols, a list of tables and a bibliographical list (82 references).

Chapter 1 constitutes the introduction, It presents the context and background as well as the interest of the research topic, define the aims and objectives of the work research and Summarize the structure of the thesis.

Chapter 2 presents a literature review on type I kerogen of world-known deposits of various ages (from the Paleozoic to the Cenozoic) and from different parts of the world : Colorado, Utah, and Wyoming (USA), Baltic Shale basin, Nova Scotia (Canada), East China, central Germany and Poland, Tasmania in Australia, and Catalonia in Spain. It focuses on geochemical characterization of organic matter and the main factors controlling the formation of organic-rich deposits.

Chapter 3 is dedicated to the presentation of the materials and the methods. It outlines the scientific approach adopted and different types of analyses, which have been considered to achieve the scientific objectives. 60 cross –sections including the Bazhenov Formation and stratigraphic analogues of Tithonian – early Valanginian and a total of 28 samples of the alginite-rich layers as well as 34 samples of the surrounding rocks were studied. "The alginite-rich layers", were first identified in several wells drilled. Afterwards thin section petrography, organic petrography, Rock-Eval pyrolysis, kinetics, elemental analysis, GC-GC-MS, and isotope analysis, were used to determine distinctive features of these layers and to evaluate their impact on the total petroleum generation potential of the Bazhenov Formation.

Chapter 4, 5 and 6 correspond to the main contribution It presents the results of the analyses conducted by the candidate. **Chapter 4**: deals with lithological characterization and inorganic geochemistry of "the alginite-rich layers". **Chapters 5** focuses on the organic geochemistry, maceral analysis and stable isotope composition of the "The alginite-rich layers". **Chapters 6** is devoted to the modeling of thermal maturation and hydrocarbon generation of the type I Kerogen.

The conclusion summarizes the thesis's main results and significant findings and gives recommendations for future work.

The relevance of the topic of dissertation work to its actual content

The topic of the dissertation is in relevance to its actual content and it's both of great scientific and economic values. Indeed the results obtained have implications in depositional environment reconstruction and in geological correlation, and basin modeling. Otherwise, It is important to study the organic matter type, thermal maturity and depositional environmental of the Bazhenov Formation which constitutes a promising unconventional reservoir for Russia. Admixture of type

I kerogen in the Bazhenov deposits has been mentioned previously in recent studies, but a detailed characterization has never been presented.

The relevance of the methods used in the dissertation

The methods used are relevant to the research goals and the topic of the thesis. Different analyses were conducted ranging from the visual description of the cores to the experimental techniques that are available for the characterization of the microscopic and chemical particles. The multidisciplinary and multiproxy approach attests to the skills acquired by the candidate in the petroleum exploration domains.

The scientific significance of the results obtained and their compliance with the international level and current state of the art

The research work done for this thesis is of high quality and of international relevance. It provides new insight with important global implications. Alginite-rich layers containing pure type I kerogen., were identified for the first time in 27 wells in Late Jurassic-Early Cretaceous marine organic-rich Bazhenov shales located in the central part of the West Siberian Petroleum Basin. These layers are interpreted as algal bloom events, stimulated by nutrient additions supplied by a different source. These findings have implications on depositional environments reconstruction, stratigraphic and paleogeographic correlations as well as basin modeling.

The relevance of the obtained results to applications (if applicable)

The candidate clearly demonstrates important abilities in the domain of Petroleum Engineering. Otherwise, all the obtained results are applicable in the field of petroleum exploration. And lost but not least the West Siberian Petroleum Basin is now the focus of a regional petroleum prospective assessment. It is poised to become Russia's next major unconventional shale oil province.

The quality of publications

The quality and the interest of the results obtained are clearly demonstrate through the number of publications. The candidate has: 4 publications in International peer-reviewed journals: Geosciences and Moscow University Geology Bulletin, 3 side topic articles, and 22 extended abstracts in international conferences and congress.

In summary, the thesis represents a high quality research work. In addition, the structure of the dissertation is coherent and the manuscript is well- written and well- illustrated with 47 figures and 15 tables. It clearly shows the competences of Timur Bulato in his field of investigation. It reflects sufficient competences in the survey of literature an ability to set the targets. It also shows all knowledge and skills he acquire to conduct such scientific research.

I consider the content of this thesis as very good and it certainly meets the requirements for obtaining a Doctor degree. I recommend without reserve to allow Timur Bulatov to defend his thesis in front of a jury.

However, I have some comments that are listed below concerning minor shortcomings and corrections

The summary of issues to be addressed before/during the thesis defense

1/ It's more appropriate to replace "lithological methods with "Sedimentological methods" in all the manuscript (abstract, Introduction, chapter 3 etc.…), because the techniques used are: Thin section petrography, Organic petrography, Scanning electron microscopy, and X-Ray diffraction

2/ It would be useful to add in Chapter 2 a bibliographical synthesis on the geological and geodynamic context of the Upper Jurassic – Lower Cretaceous Bazhenov Formation and the West Siberian Petroleum Basin. Such compilation may help to validate and support the proposed interpretations

3/ "Accepted classifications" (3.3, L.3, Pages. 43 and 44)
"Accepted classifications should be replaced with "Adopted stratigraphic subdivisions and classification"
3.3.1 Tectonic units
3.3.2 ~~3.3.3 Stratification~~ Stratigraphy of the Bazhenov sequence
3.3.3 ~~3.3.2~~ Thermal maturity of organic matter

4/ What do you mean by "facial settings" ? (L 2 of the summary of chapter 2)

5/ According to Figure 4.1.1. in Page 45, it seems that you have at least 4 different sedimentary facies. It would be useful to conduct a sedimentary facies analysis of the core. The study of sedimentary facies is of great value for oil exploration. In addition to recognition and palaeogeographic reconstruction of sedimentary environments, it helps to better analyze the reservoir characteristics

6/ There is no consistency between what is written in Paragraph. 2 (L.1 & 2), Page 46: "Usually, the alginite-rich layers pass gradually to the organic-rich siliceous rocks. This gradation gives the rocks a banded appearance under UV light" and in the title of Figure 4.1.2 (Page 46) "Photographs of the alginite-rich layers under white (a, c) and UV light (b, d) showing normal grading". Normal grading is used when coarse sediments grade upwards into progressively finer ones

7/ Pelitic structure is not an appropriate (L2, Paragraph 2, Page 47) it means nothing in sedimentology

8/ What do you mean by: The specific morphology of the quartz of the alginite layers (paragraph 4 , L;6 & 7, 5.10 Depositional environment) It's necessary to describe this morphology

9/ What do you mean by "eolian rafting"? (Paragraph 4, L8, 5.10 Depositional environment)

10/ Marine basins, large lakes and swamps are sedimentary environments and not sedimentary facies. So it's recommended to replace in Paragraph 6, L.3, Conclusion, Page 87

Provisional Recommendation

☒ *I recommend that the candidate should defend the thesis by means of a formal thesis defense*
☐ *I recommend that the candidate should defend the thesis by means of a formal thesis defense only after appropriate changes would be introduced in candidate's thesis according to the recommendations of the present report*
☐ *The thesis is not acceptable and I recommend that the candidate be exempt from the formal thesis defense*